Amendments to the Specification:

Please replace the first full paragraph on page 1, lines 5-8 with the following amended paragraph:

This application is related to U.S. ~~U.S.~~ Patent Application Serial No. 09/560,052 ~~______~~, entitled "Systems and Methods for Integrating 3D Diagnostic Data." The present invention relates to three-dimensional (3D) representations of objects such as anatomical structures.

Please replace the first full paragraph on page 8, lines 9-17 with the following amended paragraph:

At this point, the treating professional has available a fully explorable multi-layered representation of the skull in three dimensions. Measurements from the teeth to each other and to the surfaces of the face can be performed using a mouse-driven cursor. If the treating professional desires conventional two dimensional cephalometric information, he or she can obtain it by locating landmarks and surfaces solely on the centered lateral and centered frontal images from the emitter 310 without the emitter 312 (Figs. 3A-3B). In order to obtain full skeletal information in three dimensions, the treating professional or a trained assistant will be required to locate the same landmark on each of two stereo X-ray images using the emitters 310-312.

Please replace the first full paragraph on page 9, lines 8-21 with the following amended paragraph:

The information stored in the integration system 70 is merged to create a holistic view of the patient data from a plurality of data sources. Fig. 2 shows a process 199 which uses information from the raw data acquisition module ~~102~~ and database ~~104 of Fig. 1~~. First, an appliance containing radiopaque tie points or markers is created. The tie points are identifiable markers that are visible in multiple types of images, or across multiple time points within a single type of image. The locations of the markers are specified in advance. When digital camera 3D data is merged with stereo X-ray data, common points in both sets of images are needed. In this case, small radiopaque spheres are temporarily placed on the face of the patient. They show up as small "targets" in the digital facial images. Because they are radiopaque, they also show up in the X-rays. Then 3D coordinates are computed for these common tie points from

both the stereo X-rays and from the digital facial photographs. Once the coordinates are known from both sources, a mathematical transformation can be applied to rotate and translate the facial data into the same frame of reference as the X-ray data.

Please replace the first full paragraph on page 10, lines 6-13 with the following amended paragraph:

From step 202, 3D facial data are acquired using a 3D camera (step 204). Next, 3D coordinates for facial Tie Points from facial digital image are computed (step 210). From step 204, one or more casts ~~appliances~~ are created (step 206), and 3D coordinates for tie points on teeth computed from the casts ~~appliances~~ (step 212). The 3D coordinates are computed from the study casts for the tie points on the teeth. At this point, 3D coordinates are available for: a) anatomical features from X-rays; b) tie points on the teeth from X-rays; c) tie points on the face from X-rays and facial images; e) tie points on the study cast and therefore the model of the dentition.

Please replace the first full paragraph on page 11, lines 3-6 with the following amended paragraph:

3D coordinates of tie points on the patient's teeth and face (from X-ray Images) are transformed to an anatomical framework (step 214). Further, 3D Coordinates of Tie Points on the study casts are transformed to the teeth tie points from the stereo X-rays (step 216). From step 216, the study cast 3D data is transformed to the anatomic frame of reference using visualization software (218).

Please replace the second paragraph on page 11, lines 7-9 with the following amended paragraph:

From step 216, 3D coordinates of tie points from the patient's face (from facial digital images) are transformed to the facial tie points (now in the anatomical frame of reference) from stereo X-rays (step 220). From step 220, the facial imagery is transformed to the anatomic frame of reference using visualization software (222).

Please replace the last paragraph starting on page 12, line 22 and ending page 13, line 7 with the following amended paragraph:

This embodiment includes a rigid rectangular structure with twin HRT1 General Electric X-ray emitters 310-312 mounted at one end. At the opposite end of the stereo X-ray imaging system, beyond the patient's head is a machined cassette holder defining the datum plane 319 ~~318~~. The emitters 310-312 and the carrier or cassette holder 318 taken together constitute the "cameras" of the stereo system. The relationship between the cassette holder 318 and both X-ray emitters 310-312 is known through previous use of a calibration device. The calibration process consists of imaging a calibration cage with three planes of precisely known radiopaque targets. Using a simultaneous least squares adjustment ("bundle adjustment"), the 3D locations of the X-ray emitters are determined.

Please replace the first full paragraph on page 13, lines 8-18 with the following amended paragraph:

The mathematical calculation of the 3D positions of the tie points and anatomical structures on the stereo X-ray images depend ~~depends~~ upon having accurate and precise information on the physical relationships between the focal spots of the two entities (310 and 312) and the surface of the X-ray film or its digital equivalent located in the cassette carrier at 318. The information needed includes: (1) the distance between the two focal spots 310 and 312, measured parallel to the surface of the film in the cassette carrier; (2) the perpendicular distance between each focal spot and the plane of the film surface, and (3) the precise location of the cassette within the cassette carrier for each exposure. This location differs slightly for different projections as may be seen by examining the X-ray intersections ~~316 and 318~~ in Fig. 3A ~~3a~~. To obtain this data, a calibrated array, the cassette carrier previous mentioned, and an "auxiliary calibration checking frame."

Please replace the last paragraph starting on page 13, line 19 and ending on page 14, line 13 with the following amended paragraph:

Figs. 4A-4D illustrate an exemplary calibration array 500. An imageable structure of known dimensions is placed in a location from which it can be X-rayed. The structure consists of a radiolucent framework upon which are mounted a number of radiopaque points whose three space locations with respect to each other are known with accuracy and precision. In the simplified illustrated case there are four perpendicular radiolucent plastic rods 502, 504, 506 and

508 at the top and bottom of which the radiopaque points are mounted perpendicular to each other. When the X-ray image is exposed, the shadow points 503, 505, 507 and 509 of the top of the rods 502, 504, 506 and 508 will be cast upon the film surface, radially displaced with respect to the original three space position of the rod top point. A line drawn in three space which passes through both any rod top point and the image of that point on the X-ray film will also pass back along the path of the ray which erected the image through the focal spot from which the ray originated. This principle is shown in photogrammetry as the principle of resection. Since the same principle applies to all four rods, a series of lines passing through an X-ray focal spot ~~510~~ (corresponding to point 310 or 312 of Fig. 3A) may be generated, the intersection of any two of which would identify the focal spot uniquely if the measurements were without error. Since there is always error, redundancy is added in this implementation by the use of four rods rather than two.

Please replace the last paragraph starting on page 14, line 20 and ending on page 15, line 3 with the following amended paragraph:

To locate the principle point for each X-ray source, a line is drawn in the plane of the film passing through the images of each rod top point and its rod own bottom point. Information from two rods can be used in the absence of measurement error and the redundant information arising from the use <u>of</u> ~~o~~ four rods strengthens the calculations in the presence of error. At this point, the distance from each X-ray source to the film plane, the point of contacts on the film plane of the principle ray from each source, and the distance between the two X-ray sources are known.

Please replace the last paragraph starting on page 15, line 18 and ending on page 16, line 2 with the following amended paragraph:

The next task is to obtain precise information about the precise orientation of the film cassette with respect to X-ray emitters. For this purpose, a cassette holder 318 (Figs. 5A-5B) is rigidly attached to X-ray emitters or sources 310 and 312. The holder 318 has on its surface a set of precisely positioned radiopaque fiducial points (<u>325</u> ~~324~~ being typical) whose precise coordinates are known through direct measurements. These fiducials, in sets of at least four are

imaged on the film surface during exposure, thus identifying the precise position of each film with respect to its X-ray source.

Please replace the last paragraph starting on page 16, line 22 and ending on page 17, line 6 with the following amended paragraph:

After producing the stereopair of lateral skull films, the patient and the cephalostat are next rotated 90 degrees such that the patient faces the cassette carrier 318. Two more films are exposed from the first and second stations. These constitute a frontal X-ray stereopair. The film ~~films~~ pairs are processed and examined by a monocular analytic method in which a person examines the two images sequentially and marks the locations of the cassette holder fiducial points, the tie points, and one or more sets of anatomical landmarks. The location of these structures on the X-ray images can be done manually or by using suitable computer programs.

Please replace the last paragraph starting on page 17, line 14 and ending on page 18, line 4 with the following amended paragraph:

The coordinate files for the two films of each stereopair are now used to produce a three dimensional map in the following manner. The file for the film from second camera station ~~312~~ (the offset film) is rotated and translated such that its four registration points are best fit upon the registration points of the film from the first camera station ~~310~~ (the centered film). The X parallax of each point in the system may now readily be computed as the ΔX between any landmark on the "centered" film and its conjugate on the "offset" film, and the altitude of the landmark is computed automatically using standard photogrammetric equations. In addition, the Y parallax for each landmark and registration point is computed as measure of the degree to which the same physical structure was actually identified on both films of the stereopair. More information on the transformations is described in Elements of Photogrammetry, Paul R Wolf, McGraw-Hill (1974). Systematic Y parallax deviation for anatomical landmarks which are significantly greater than those for the fiducials are indicators of patient movement between the exposure of the two images of the stereopair.

Please replace the first full paragraph on page 18, lines 5-16 with the following amended paragraph:

In one embodiment, the raw data acquisition module ~~102~~ receives 3D facial data from a 3D camera such as the Venus3D camera available from 3DMetrics of Petaluma, California. The 3DMetrics camera uses a 3D Flash light projector and a conventional digital camera. The 3D Flash light projector projects a color-coded white light pattern onto an object, the digital camera takes an image of the object, then the data is transmitted to a computer which performs a cross-talk-free-color-decoding operation. The 2D data is then converted into a 3D image. In this manner, the 3D camera or imaging system enables a single regular digital camera to take a 3D image with only one shot and does not require any additional mechanical scanning, laser light source, or additional shots. The 3D data generated by the 3D camera is then scanned for the location of tie points. In one embodiment, the tie points are manually identified by a person. Other embodiments would provide automatic detection of the tie points.

Please replace the first full paragraph on page 19, lines 3-8 with the following amended paragraph:

Fig. 6 shows two views of a tie point fitting used with for use with a direct bonding onto the teeth of a patient. The tie point fitting has a plastic carrier <u>332</u> ~~330~~. Mounted on top of the plastic carrier <u>332</u> ~~330~~ is a radio opaque tie point <u>330</u> ~~332~~. As shown in the side view and the edge view, the plastic carrier <u>332</u> ~~330~~ has serrations at a bottom end to facilitate mounting of the tie points <u>330</u> ~~332~~ onto a tooth of a patient using a suitable glue or bonding system.

Please replace the last paragraph starting on page 19, line 12 and ending on page 20, line 3 with the following amended paragraph:

Next, appliances with radiographic markers will be discussed. In one implementation, radiographic markers are embedded in an appliance 300, shown in Figs. 8A and 8B. The appliance 300 is a polymeric shell having a cavity shaped to receive teeth. The polymeric shell typically fits over all teeth present in the upper or lower jaw. The polymeric appliance 300 is preferably formed from a thin sheet of a suitable elastomeric polymeric, such as Tru-Tain 0.03 in. thermal forming dental material, marketed by Tru-Tain Plastics, Rochester, Minnesota 55902. The appliance 300 has four radiopaque metal pins 302, 304, 306 and 308. In one embodiment, the radiographic markers or tie points are stainless steel spheres that are 3/32" in diameter, grade 100 material with sphericity within 0.0001 inch and with a hardness rating of Rockwell C 39.

Only three tie points are sufficient to determine a common plane for merging two 3D maps if they are located perfectly. However some redundancy is desirable and so the present system employs a minimum of four. Although four tie points are shown in Figs. 8A-8B, six tie points can be used in the event that the patient has fillings that in some way obscure some of the tie points in the X-ray images.

Please replace the first full paragraph on page 20, lines 4-17 with the following amended paragraph:

One procedure for creating the appliance 300 with the radiographic tie points 302-308 is discussed next. First, a dental professional takes one or more PVS impressions and a wax bite for measuring inter-arch relationship. The impressions are used to generate one or more models, which are then scanned. The dental professional then sets up a bite registration of both arches, and tooth-attachments are mounted onto the desired teeth which is exactly the same size and shape of the actual tie points 302-308. In one embodiment, the attachments are mounted on three teeth in each quadrant (canines, first molars and second molars for a total of twelve attachments in both arches. Aligners are then fabricated with sufficient spaces for retaining the tie points 302-308. The tie points 302-308 are positioned onto the spaces, and a thin film of unfilled composite adhesive is applied to secure the tie points 302-308. Next, the dental professional opens the occlusal surface of aligners to establish contact between the opposing maxilla and mandible casts. Further, the dental professional can polish the appliance 300 to make it more comfortable to wear.

Please replace the first full paragraph on page 23, lines 1-2 with the following amended paragraph:

The two dimensional coordinates of all points can be used to produce a single integrated dimensional craniofacial map.

Please replace the last paragraph starting on page 24, line 20 and ending on page 25, line 7 with the following amended paragraph:

Fig. 11 is a simplified block diagram of a data processing system 600 that may be used to generate the appliance 300 of Figs. 8A-8B ~~3A-3B~~. The data processing system 600 typically includes at least one processor 602 that communicates with a number of peripheral devices via

bus subsystem 604. These peripheral devices typically include a storage subsystem 606 (memory subsystem 608 and file storage subsystem 614), a set of user interface input and output devices 618, and an interface to outside networks 616, including the public switched telephone network. This interface is shown schematically as "Modems and Network Interface" block 616, and is coupled to corresponding interface devices in other data processing systems via communication network interface 624. Data processing system 600 could be a terminal or a low-end personal computer or a high-end personal computer, workstation or mainframe.